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Some Practical Methods for the Evaluation of Lubricating Greases

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Introduction

Greases are used for a wide variety of applications. They are usually sold according to consumer's specifications or on the manufacturer's recommendations. Specifications generally include such tests as free acidity and alkalinity, dropping point, and penetration. These tests are of little use in predicting the suitability of the lubricant for a given application and only ensure uniformity in successive shipments of the same grease. As a result, the majority of grease manufacturers rely on field tests to determine the suitability of their products. In some cases field testing has reached prodigious proportions, and it is not uncommon for some manufacturers to employ whole fleets of trucks for testing chassis lubricants and wheel bearing greases. While field trials are necessary to confirm laboratory data, they may give misleading results, particularly if the grease is not tested under all conditions met in service, or if the trials are not carefully and constantly supervised.

In view of the present lack of methods for evaluating the performance of greases many consumers have included tests in their specifications to cover the behaviour of the grease for a particular service. For instance, the U. S. Army-Navy G 3 specifications contain a torque test to evaluate aircraft greases for low temperature service. If the development of test methods by various consumers is allowed to progress in this manner a number of specifications covering essentially the same product will be issued and each specification will contain a different test to cover the same requirement. This will not only lead to the development of a number of test methods for the same purpose but will also require grease manufacturers to supply a number of products intended for the same service. In view of this trend, it would seem desirable for grease manufacturers to take the lead and to co-operate with equipment manufacturers in making available standardized methods which will evaluate greases for specific pur-

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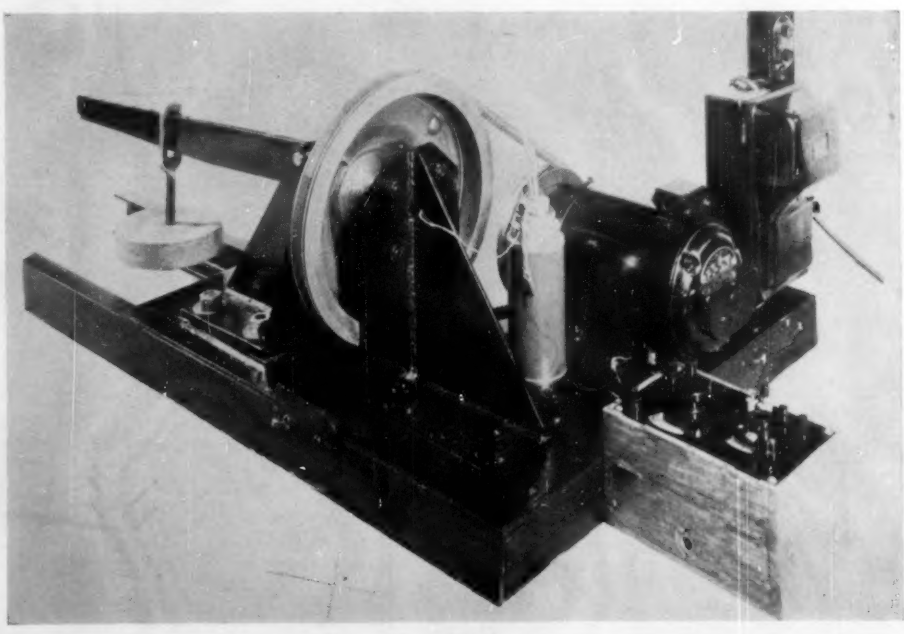

Figure No. I
Apparatus for Evaluating Wheel Bearing Greases

poses, and which can be used as a basis for specifications.

The purpose of this paper is to describe a number of laboratory methods which have been found suitable for the evaluation of:

(a) Wheel Bearing Greases
(b) The Consumption Characteristics of Brick or Block Greases
(c) The Water Resistance of Greases
(d) The Low Temperature Properties of Greases
(e) Chassis Lubricants

(a) THE EVALUATION OF WHEEL BEARING GREASES.

Several previous investigators have employed laboratory machines for the evaluation of wheel bearing greases. Blackwood and Spencer used [1] a machine consisting of two wheel bearing assemblies separated by a calibrated spring. The tension of the spring was used as a means for loading the bearings. Klemgard [2] also described a machine for this purpose.

The apparatus used for evaluating Wheel Bearing Greases was similar to that developed by Klemgard, and consists of a front-wheel hub and spindle assembly from a 1938 Ford car driven by a ½ h.p. electric motor. Figure No. I shows the general disposition of the parts and the method of loading.

The bearings were loaded by pressing a cam against the inner race of the outboard bearing by means of weights and a lever arm. Thus any desired radial load may be obtained by application of an axial load. In order to obtain bearing temperatures the spindle was drilled, and a thermocouple was inserted against the inner race of both the inboard and outboard bearings.

A test was carried out by weighing the outer bearing to the closest 1/10th of a mgm. and then packing it with 5 gms. of grease. The machine was assembled and run for 6 days at 800 r.p.m. which is equivalent to a road speed of 70 m.p.h. over a period of about 10,000 miles. The total axial load on the cam pressing against the bearing was 456 pounds. To determine the efficiency of Wheel Bearing Grease the amount of grease remaining in the bearing, the bearing wear, and the temperature developed in the bearing were measured. Typical results for three greases are shown in Figure No. II.

Grease A *Grease B* *Grease C*

FIGURE No. III

Photographs of Wheel Bearings After Test

Grease A consists of 14% soda lime soap in a 46 S.U. at 210°F. viscosity oil and has a dropping point of 195°F. In the wheel bearing test the maximum temperature developed was 214°F. and examination of the bearing showed a large amount of wear, approximately 25 mgms. The poor results obtained with this grease were due to the high operating temperature of the bearing which caused the grease to melt and run out of the bearing.

Grease B was a long fibre grease consisting of 8% soda soap in a 190 S.U. at 210°F. oil and possessed a dropping point of 400°F. The wheel bearing test on this grease was considerably better — showing 9 mgms. wear. The maximum temperature developed in the bearing was 181°F. On completion of the test only 28% of the original grease remained in the bearing. It is believed that the fibrous nature of the grease caused it to be pulled out of the bearing thereby providing insufficient lubrication.

Grease C was a short fibre grease consisting of 17.6% soda soap in a 60 viscosity at 210°F. mineral oil and had a dropping point of 363°F. The wheel bearing test gave excellent results showing no wear on the bearing. The maximum temperature developed was ideally low, being 132°F.

The photographs of the bearings after test are shown in Figure No. III.

In the above photograph the dark areas on the rollers show where wear has taken place. It is evident that the amount of wear judged by visual observation agrees with the loss in weight of the bearings shown in Figure No. II. In the normal operation of wheel bearings, the extent of the wear would not be nearly so high as shown in these tests. Under severe condi-

FIGURE No. II

Results of Wheel Bearing Tests

Designation	A	B	C
Type of Grease			
Soap Content %	14.0	8.0	17.6
Dropping Point, °F.	195	400	363
Visc. S U. @ 210° F. of Mineral Oil	46	190	60
Wkd. Pen at 77° F.	328	283	245
Wheel Bearing Test			
Maximum Temp. °F.	214	181	132
Grease left in bearing %	16	28	45
Loss in wt., rollers mgms.	25.2	9.0	Nil
cup mgms.	7.0	0.3	1.4

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tions of load and speed, lubrication becomes more critical. The test procedure was purposely chosen to indicate the relative performance of greases under severe conditions for the type of equipment commonly used in Canada. In making laboratory tests with this procedure it is advisable to use the same manufacturer's bearings for all tests. Bearings of the same type made by several manufacturers may have different clearances which will affect the results.

Wheel bearing greases selected on the basis of this method of evaluation have given excellent performance in the field.

(b) The Consumption Characteristics of Brick Greases

Brick or block greases are used to lubricate half-journal bearings of paper machines, mining equipment, cement kilns, etc. The conditions of operation cover a wide range of speed and temperature. The speed of such journals varies from 10 to 200 ft./min. and the operating temperature may be as high as 300°F. In practice, brick greases are generally selected on the basis of minimum consumption consistent with adequate lubrication. Field experience in Canada has shown wide differences in the consumption of various types of brick greases used for a specific application and it was found necessary to develop a means of evaluating the consumption characteristics of this type of grease in the laboratory.

A photograph of the apparatus for this purpose is shown in Figure No. IV.

It consists of a steel journal 8 inches in diameter and 14 inches long supported by two anti-friction bearings. The half-bearing is made of bronze and is held against the journal by means of weights and a lever arm. This mechanism also provides a method of applying a load to the bearing. Equipment is also available to heat the journal electrically to any desired temperature. Variable speed is obtained by means of a Reeves drive. The temperature of the bearing is continuously recorded by two thermocouples placed in the half-bearing ⅛ inch from the surface adjacent to the journal.

Results of tests showing the effect of speed and temperature on consumption characteristics for three greases are shown in Graphs I and II of Figure No. V.

It will be observed from Graphs I and II that both temperature and speed have an effect on the consumption characteristics. Increasing the speed from 38 to 167 ft./min. while maintaining the temperature constant at 250 to 260°F. caused the consumption to double. The effect of temperature at a constant speed of 167 ft./min. shown in Graph II was more marked. Grease A showed relatively low consumption up to 250°F. As the temperature was increased the consumption increased rapidly and the grease finally melted and ran through the bearing at about 270-280°F. This grease had an A.S.T.M. dropping point of 376°F. thus showing that dropping point alone does not necessarily indicate the high temperature characteristics of a grease in this type of service. Greases B and C had essentially the same physical characteristics such as dropping point, soap content, and mineral oil viscosity. Nevertheless, the consumption of Grease B is extremely high throughout the whole tem-

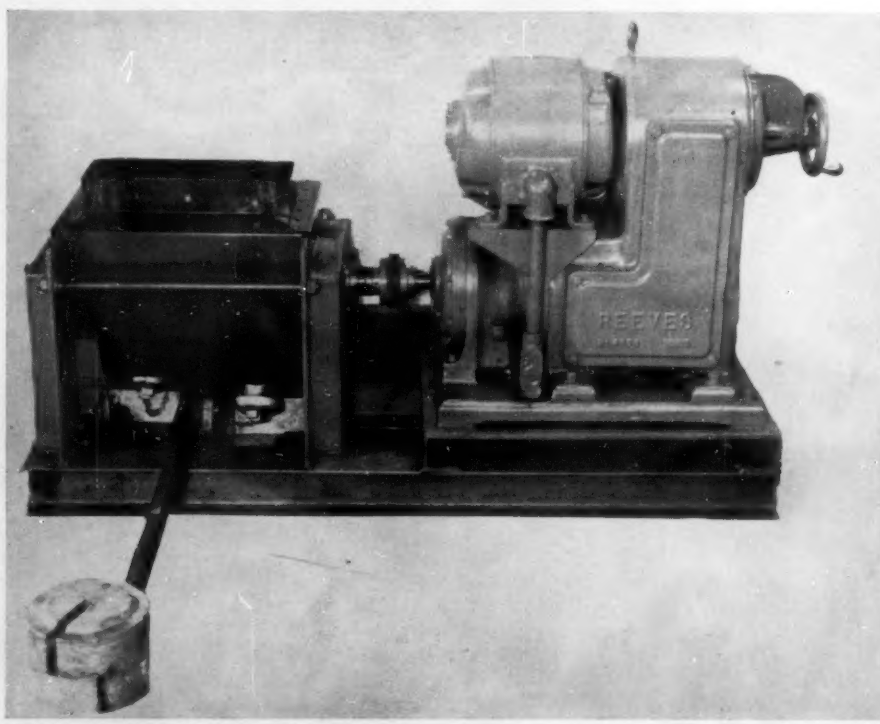


Figure No. IV
Laboratory Apparatus for Evaluating Brick Greases

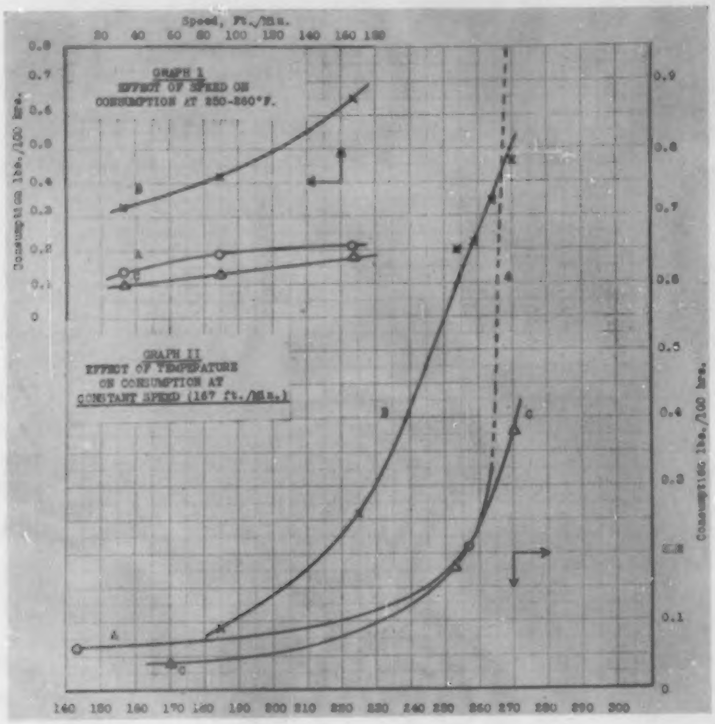


FIGURE No. V

Results of Laboratory Evaluation of Brick Greases
Temperature, °F.

	Soap, %	Brick Greases Mineral Oil	Dropping Point
A	26 (Soda-lime)	40	376
B	17 (Soda)	95	350
C	14 (Soda)	80	374

FIGURE No. VI

Water Resistance of Greases

Type	% Soap	Wkd. Pen. at 77°F.	Water Absorption (c.c.) 75°F.	100°F	125°F.	150°F	200°F.
Lime	14.0	287	20	18	16	14	12
Lithium	12.0	260	....	12	....	....	13
Aluminum	9.0	260	15	13	19	30	16
Sodium	19.8	287	30	24	Emulsion at 80 c.c.	....	....
Sodium	20.0	263	Emulsion at 40 c.c.	....	....	....	....

perature range while Grease C showed uniformly lower consumption under similar conditions of operation. It is interesting to note that in general the consumption between 200 and 250°F. doubled for every 20°F. increase in temperature.

A limited number of field tests showed the same general effect of speed and temperature on the consumption characteristics of brick greases. A direct correlation could not be obtained as the bearings of industrial equipment and the laboratory machine were not the same size.

(c) WATER RESISTANCE OF GREASES.

Many of the present specifications for greases have included tests for indicating their water resistance properties. For instance, in Chrysler MS 1805 specification covering wheel bearing greases, a steel panel is coated with the grease under test and subjected to a water spray under controlled conditions. The amount of grease washed from the panel is used as a measure of its water resistance.

A new method which was found convenient for this purpose consisted of placing 100 grams of grease in an A.S.T.M. worker, adding 20 c.c. of water, and working by means of a power worker at a rate of 30 strokes a minute for 10 minutes. The grease was then examined visually and if no free water were present an additional 20 c.c. of water was added and the grease was worked again for 10 minutes. This operation was repeated until free water was present or the grease broke down to a thin emulsion. The test is carried out at constant temperature by circulating oil through a jacket surrounding the worker. A grease showing the least absorption of water while retaining its consistency was considered to be the most water resistant. Greases which emulsified with water and became liquid possessed no water resistance. Figure No. VI shows the results on a number of greases.

The greases examined had a worked penetration of about 260-290 and contained a 300 S.U. at 100°F. viscosity oil. Water resistance measurements were made over the range 75-200°F. It will be observed that lime, lithium, and aluminum soap greases are highly resistant to water up to temperatures of 200°F. In the case of the two soda soap greases, one was found satisfactory at 100°F. while the other possessed no water resistance.

In general, it can be concluded that lime, lithium, and aluminum soap greases are water resistant. The degree of water resistance is, however, influenced by many factors such as the temperature at which the test is carried out, soap content, and mineral oil viscosity of the grease, etc., and to obtain comparable data it is necessary to make determinations on each product. This

is even more marked in the case of soda soap greases.

This method could, of course, yield further information by measuring the consistency of the grease on completion of the test by determining the A.S.T.M. penetration.

(d) Low Temperature Properties of Greases.

It is generally accepted that measurement of viscosity is the most direct method for predicting the performance of lubricants at low temperatures. The viscosity of greases can be determined by means of a pressure viscometer. Figure No. VII shows the viscosity temperature relationships of a number of boiled lime soap greases measured at 340 sec. $^{-1}$ rate of shear.

Greases Nos. 1 and 4 have approximately 12-13% soap content and contain 115 and 851 S.U. at 100°F. viscosity mineral oils respectively. Their viscosities at −10°F. were 180 and 2800 stokes respectively. The effect of soap content is shown by comparing Greases No. 2 and 3 which contain 9.8% and 15.8% soap in a 312 S.U. at 100°F. viscosity oil. An increase in soap of 6% caused the viscosity to increase from 620 stokes to 1520 stokes. No doubt a correlation could be established showing the effect of the variables, namely temperature, rate of shear, mineral oil viscosity and soap content on the viscosity of greases.

During tests on the lubrication of some industrial equipment at low temperatures it was observed that certain greases having a high viscosity at low temperatures possessed excellent low-temperature characteristics from the standpoint of torque requirements. This was particularly true in the lubrication of certain anti-friction bearing applications. In view of this an effort was made to correlate grease viscosity and torque measurements in a 1″ x 1-¼″ sleeve bearing and a Norma Hoffman 2″ cageless anti-friction bearing. The apparatus for measuring the torque at low temperatures using the sleeve bearing is shown in Figure No. VIII.

It consisted of a brass housing 4″ in diameter and 2″ long which was attached at one end by means of a sleeve to the inside of an insulated bath. The other end of the housing was equipped with a removable cover. The bearing was rotated by a shaft which projected from the housing, through the sleeve to the outside of the bath. The shaft was driven at the desired speed by the use of interchangeable gears. The housing was equipped with two ¾″ brass tubes which led from the interior of the housing to above the level of the liquid in the bath. One tube was placed directly above the circumference of the bearing contained in the housing. A cord was attached to the circumference of the bearing and led through the tube to a 25 lb. scale situated directly above the tube. The other tube, placed at approximately 45° angle with respect to the first tube, contained a 3-junction thermocouple which was attached to the bearing in order to measure the temperature. Prior to making torque measurements at low temperatures the bearing was filled with a grease to be tested and run in at

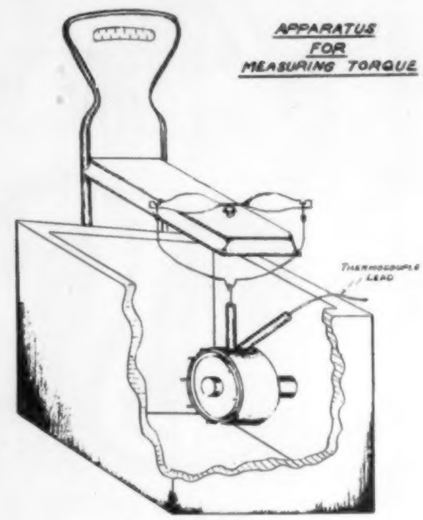


Figure No. VIII

room temperature for 5 minutes at 45 r.p.m. under a 1500 gm. load. The temperature was then lowered to −10°F. and maintained for half an hour. The maximum torque and the torque after 15 minutes' operation (running torque) were determined under no load at 340 sec. $^{-1}$ rate of shear with the sleeve bearing and at 3.3 r.p.m. with the anti-friction bearing.

(To be continued)

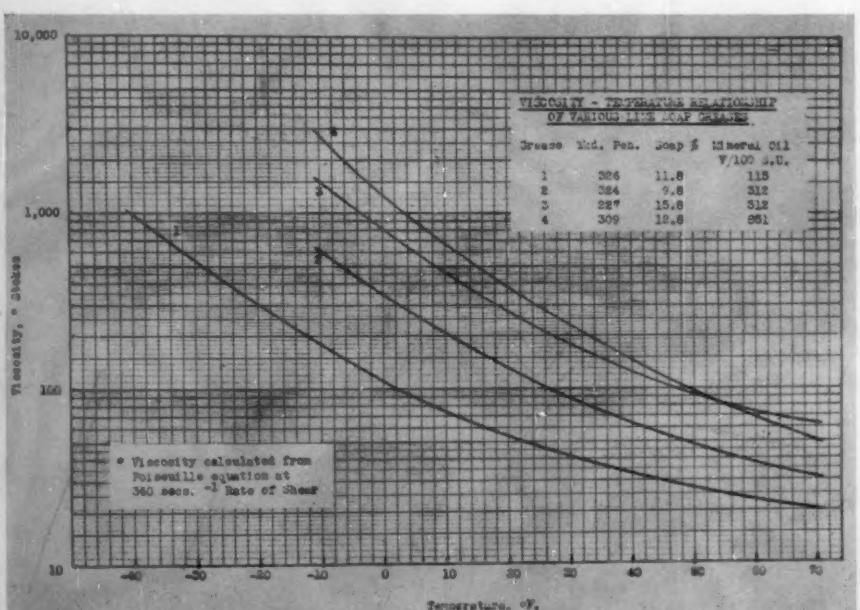
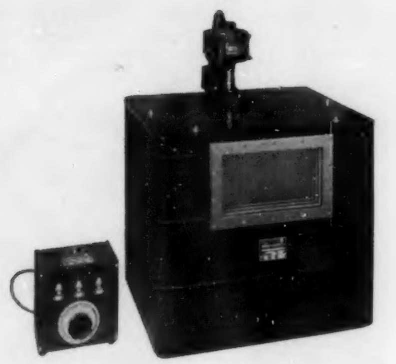
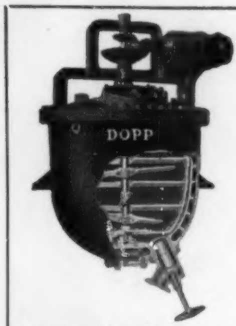


Figure No. VII

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